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Revisionary Systematics of the Western Pacific Soft Coral Genus *Minabea* (Octocorallia: Alcyoniidae), with Descriptions of a Related New Genus and Species from the Indo-Pacific

by

Gary C. Williams

Department of Invertebrate Zoology and Geology, California Academy of Sciences
Golden Gate Park, San Francisco, California 94118

and

Philip Alderslade

Museum and Art Gallery of the Northern Territory, GPO Box 4646
Darwin, Northern Territory, 0801, Australia

The dimorphic soft coral genus *Minabea* Utinomi, 1957, originally described from Japan, is here recognized as a monotypic taxon and restricted to the type species, which is designated as *Minabea phalloides* (Benham, 1928). *Minabea ozakii* Utinomi, 1957, previously recognized as the type species, cannot be morphologically differentiated from *M. phalloides*, and is therefore considered a synonym. In light of the present situation in which Benham's and Utinomi's type specimens cannot be located, and Benham's type locality is uncertain, recently collected material from New Zealand is here described in detail.

Eight other taxa, including one new species, which superficially resemble *Minabea*, are allocated to a new genus, which is morphologically distinct and has an Indo-West Pacific distribution. The new species has recently been discovered from Okinawa and the Philippines. The Indian Ocean specimens upon which the species *Alcyonium indicum* Thomson and Mackinnon, 1905, and *Bellonella indica* Thomson and Henderson, 1905, were based have been reexamined, and it has been determined that they are conspecific and belong to the new genus. These are compared with the new species. In addition, newly-collected material of a recently described Melanesian species has allowed for an assessment of phenotypic variability, which is the most marked of any species in the genus.

Revised keys and a table comparing the nine species in the two related genera, along with a discussion of variability and distribution, are also included.

Several genera of alcyoniid soft corals with unbranched digitiform to capitate growth form and dimorphic polyps are known. Included here are *Acrophytum* Hickson, 1900; *Anthomastus* Verrill, 1878; *Malacacanthus* J. S. Thomson, 1910; *Minabea* Utinomi, 1957; and *Verseveldtia* Williams, 1990 (see key to the dimorphic Alcyoniidae in the present paper).

Williams (1992b) monographed and revised the genus *Minabea*, in which five new species were described, and nine species were recognized as valid for the genus. A subsequent comparison of *Minabea ozakii* Utinomi, 1957 from Japan, with *Minabea phalloides* (Benham, 1928) from New Zealand, has shown that the two are morphologically indistinguishable. *Minabea phalloides* is therefore designated as the type species for the genus *Minabea*, and *M. ozakii*, previously accepted as the type species of the genus, is necessarily relegated to the status of junior synonym. A

redescription of *Minabea phalloides* (Benham, 1928) is included, from previously unavailable material.

Comparative investigation has also shown that *Minabea phalloides* can be separated on the basis of sclerite composition and siphonozooid morphology, from the seven other species previously considered to belong to the genus *Minabea*. A new generic name is proposed to accommodate these taxa. Included in this new genus is a recently discovered species from the western Pacific, which is here described as new. Specimens of an Indian Ocean species, previously described as *Bellonella indica* and *Alcyonium indicum*, are reexamined and compared with the new species. Generic revision and the new taxon description makes a total of eight species known for the new genus in addition to a single species in the genus *Minabea*.

An aspect of relevant interest is related here. One of these taxa, originally named *Minabea aldersladei* by Williams (1992b), has been used in chemical products research. Ksebati and Schmitz (1988) reported the discovery of diterpene lactones and minabeolides—a new group of withanolide lactones—all isolated from this species, which was collected from Chuuk, Micronesia.

Recently collected material, referable to a species previously described as *Minabea acroncephala* Williams, 1992b from the Solomon Islands, along with material from Fiji and the type locality in Papua New Guinea, exemplifies a high degree of morphological variation with respect to growth form, which is here assessed.

A brief review of the dimorphic genera of the Alcyoniidae is also provided, including revised keys, a table of comparative characters for the one species of *Minabea* and eight species of the new genus, and new distributional data for six taxa in the western Pacific and three in the Indian Ocean.

METHODS

Abbreviations used in the text are as follows: CAS (California Academy of Sciences, San Francisco), CRRF (Coral Reef Research Foundation, Palau), NHM (The Natural History Museum, London—formerly known as the British Museum of Natural History), NMNZ (National Museum of New Zealand, Wellington—now known as Museum of New Zealand, with collection acronym unchanged), NZOI (New Zealand Oceanographic Institute, Wellington—now known as National Institute of Water and Atmospheric Research, with collection acronym unchanged), NTM (Northern Territory Museum of Arts and Sciences, Darwin—now known as the Museum and Art Gallery of the Northern Territory, with collection acronym unchanged).

Material was collected by SCUBA or bottom trawl, and preserved in 70% ethanol. Sodium hypochlorite was used to isolate sclerites from soft coral tissues. An Olympus CH-2 compound microscope with drawing tube was used to draw sclerites, while a Hitachi S-510 scanning electron microscope was used to make scanning electron micrographs.

SYSTEMATIC ACCOUNT

KEY TO THE WORLD SPECIES OF *MINABEA* AND *PARAMINABEA* (Revised from Williams 1992b:2)

1. Sclerites include spindles derived from radiates, or slender rodlike forms 2
—Spindles and rods absent 3
2. Sclerites are radiates and slender, elongate, spiny rodlike forms which are densely distributed in the interior of the colony. Colonies elongate and fingerlike, tapering distally *Minabea phalloides*
—Sclerites are radiates and spindles derived from radiates. Colonies digitiform and cylindrical in shape *Paraminabea kosiensis*
3. Colonies lobate or digitate 4
—Colonies digitiform 5
4. Colonies digitate with 4–6 fingerlike branches emanating laterally from a thicker main stem *Paraminabea arborea*

- Colonies lobate with ≤ 3 robust lobes arising from the top of a basal stalk, or digitiform (fingerlike to clavate or dome-shaped) *Paraminabea indica*
5. Colonies digitiform (finger-shaped or cylindrical) 6
- Colonies clavate to capitate (conical or dome-shaped to torch-shaped) 9
6. Surface of coenenchyme with two distinct types and sizes of sclerites—small radiates and large robust barrels *Paraminabea cosmarioides*
- Sclerites throughout the colony are not of conspicuously disparate sizes 7
7. Polyparium forms $\geq 50\%$ total colony length. Colonies from shallow water (< 30 m) 8
- Polyparium forms $\leq 50\%$ total colony length. Colonies from deeper water (> 70 m) *Paraminabea indica*
8. Sclerites are eight-radiates and elongate barrels *Paraminabea aldersladei*
- Sclerites are radiates, robust barrels and tuberculate spheroids *Paraminabea robusta*
9. Colonies conical, short (usually wider than long); stalk inconspicuous ($<$ length of polyparium); sclerites include double stars *Paraminabea goslineri*
- Colonies dome-shaped or torch-shaped, (usually longer than wide); stalk variable in length (usually \geq length of polyparium); sclerites are exclusively barrels and radiates *Paraminabea acronocephala*

Minabea Utinomi, 1957

Minabea Utinomi, 1957:139; Utinomi and Imahara, 1976:206 (in part). Tixier-Durivault, 1987:154. Williams, 1992:2 (in part).

Anthomastus (non Verrill, 1878): Benham, 1928:79.

TYPE SPECIES. — *Anthomastus phalloides* Benham, 1928 by subsequent designation (present work); New Zealand.

REVISED GENERIC DIAGNOSIS. — Alcyoniid soft corals, digitiform (unbranched, finger-shaped and tapering distally). Polyps dimorphic. Polyparium conspicuously longer than stalk. Polyps evenly distributed over surface of polyparium, retractile, without calyces or sclerites. Siphonozooids crowded between autozooids, numerous and conspicuous, 0.4–0.7 mm in diameter, 1/3–1/2 diameter of retracted autozooids. Sclerites densely set: predominantly radiates in the surface layers, radiates and short spindles in the stalk interior, and numerous spiny rods more-or-less longitudinally disposed in the canal walls of the polypary.

DIVERSITY AND DISTRIBUTION. — A monotypic genus from central Japan (250–270 m) and New Zealand (139–179 m).

Minabea phalloides (Benham, 1928)

Figs. 1, 2, 3, 4, 15, 16

Anthomastus phalloides Benham, 1928:79.

Minabea phalloides: Utinomi and Imahara, 1976:211. Williams, 1992b:19, 23.

Minabea ozakii Utinomi, 1957:139.

MATERIAL EXAMINED. — NMNZ Cn 807 (NZOI Stn R81), New Zealand, North Island, Bay of Plenty, 37°35.9'–37.6' S 176°59.5'–59.8' E, 139–179 m depth, 20 January 1979, collected on NZOI cruise; three specimens total: two whole specimens and one partial specimen that is missing the stalk.

DESCRIPTION. — **Growth form and size.** The three specimens examined measure 43 mm and 73 mm in length (whole specimens), and 73 mm in length (partial specimen). The smallest specimen is attached to the inside of a clam shell. The three specimens vary in minimum width from 5–7 mm, and in maximum width from 16–18 mm. The specimens are elongate digitiform, slightly to distinctly curved, and are conspicuously tapered toward the rounded distal terminous (Fig. 1A represents the 73 mm whole specimen). The polyparium and stalk are distinctly demarcated. The polyparium is longer than the stalk. The stalk constitutes 17–38% of the total colony length (Fig. 1A).

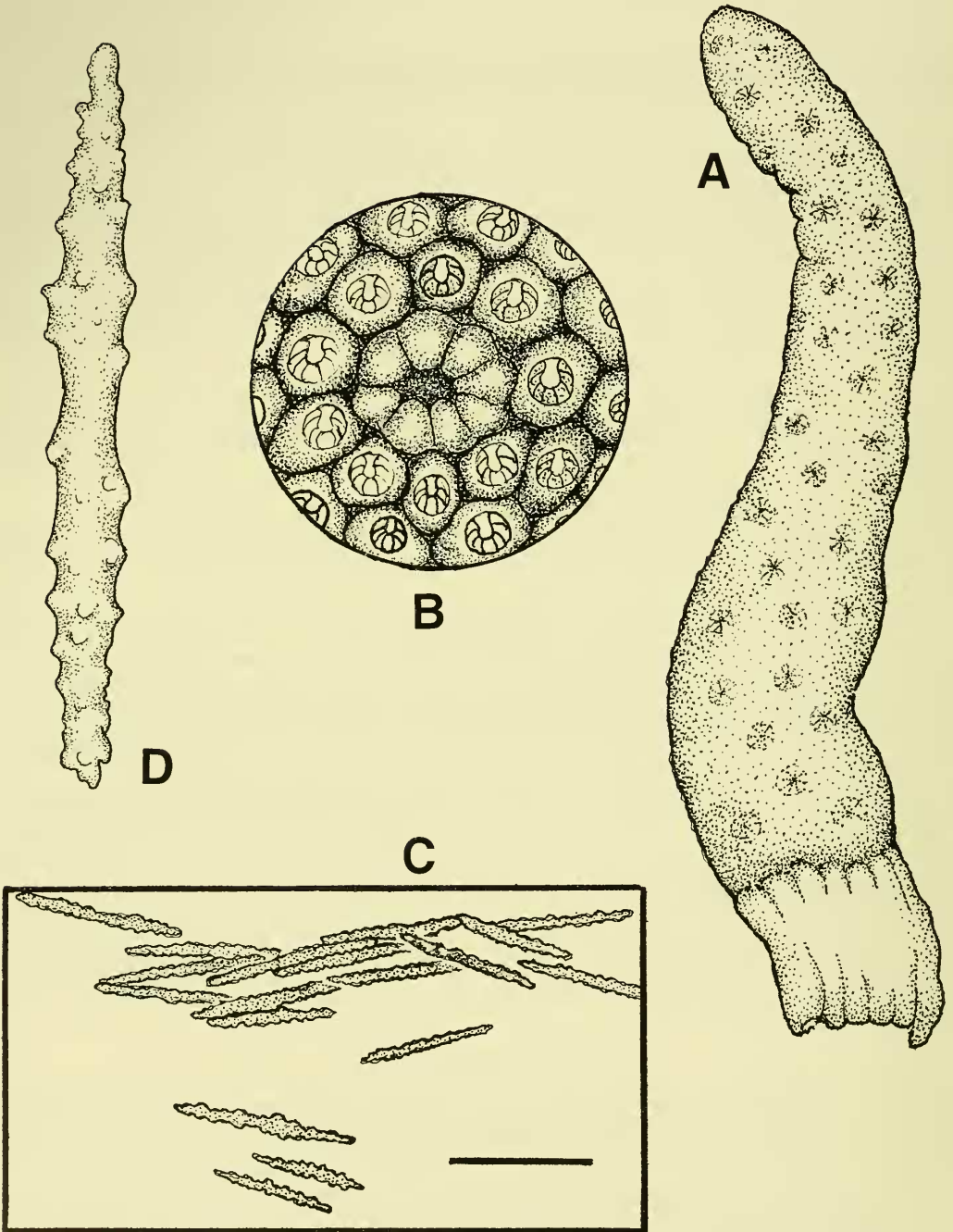


FIGURE 1. *Minabea phalloides*. A. Entire colony, 73 mm in length; B. Detail of the polyparium surface showing one autozoid and numerous siphonozoids, diameter of diagram represents 2.7 mm; C. Portion of gastric cavity wall showing disposition of sclerites of spiny rods, scale bar = 0.2 mm; D. A single rod from gastric cavity wall (polyparium interior), 0.21 mm in length.

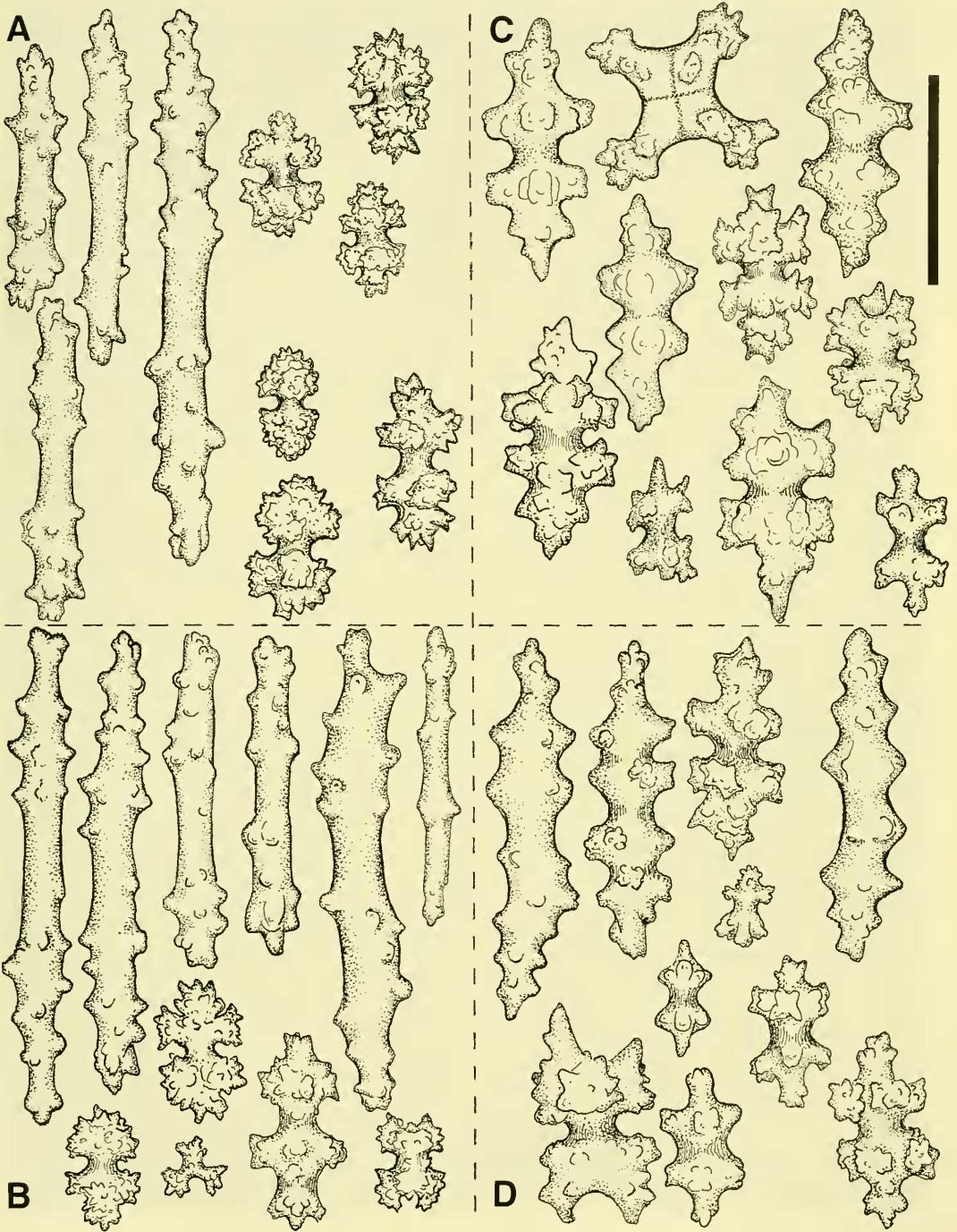


FIGURE 2. Sclerites of *Minabea phalloides*. A. Sclerites from the surface of the polyparium; B. Sclerites from the interior of the polyparium; C. Sclerites from the surface of the stalk; D. Sclerites from the interior of the stalk. Scale bar = 0.1 mm.

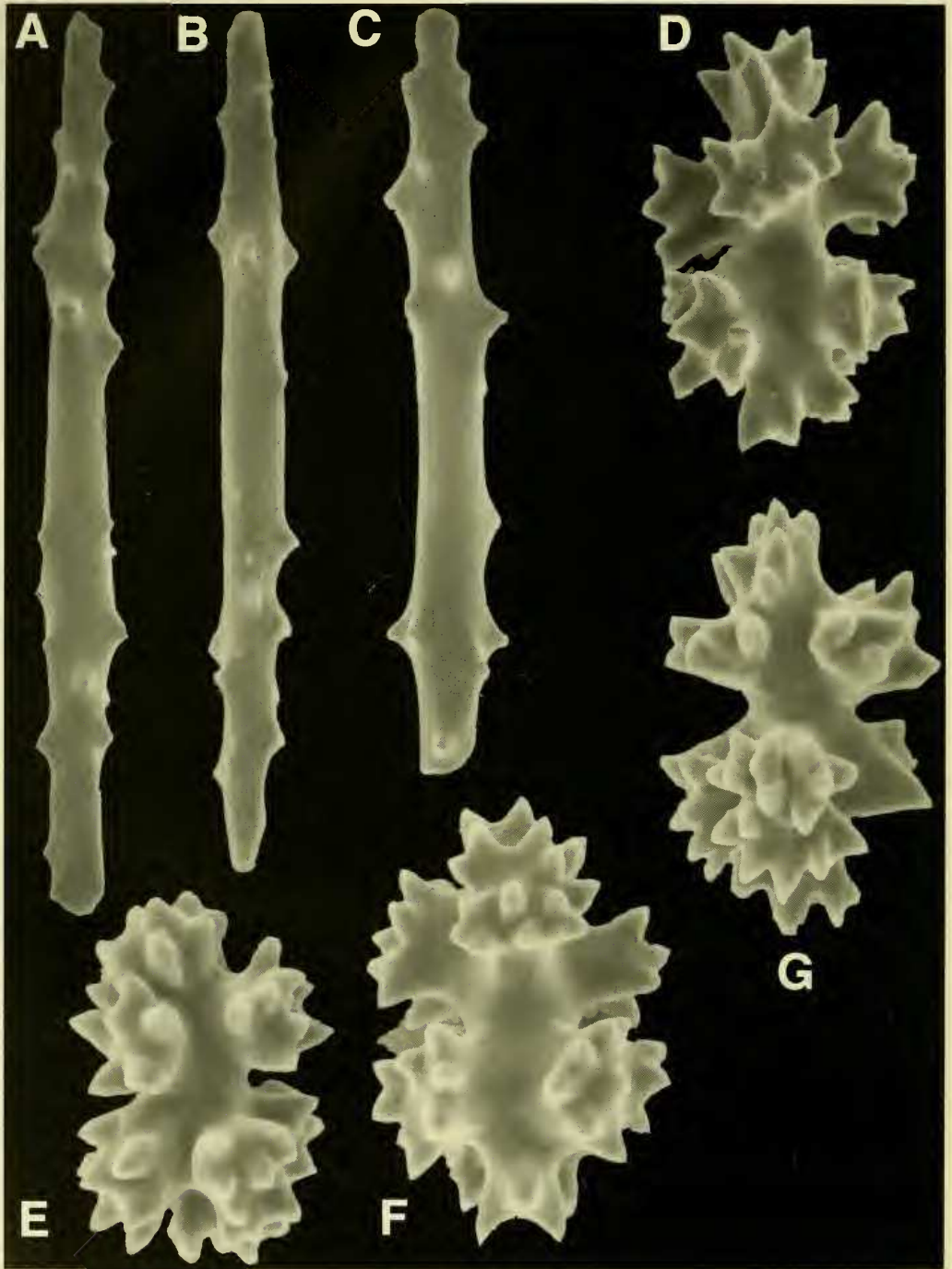


FIGURE 3. *Minabea phalloides*. Scanning electron micrographs of sclerites from the surface of the polyparium. A. 0.26 mm; B. 0.18 mm; C. 0.16 mm; D. 0.06 mm; E. 0.04 mm; F. 0.05 mm; G. 0.05 mm.

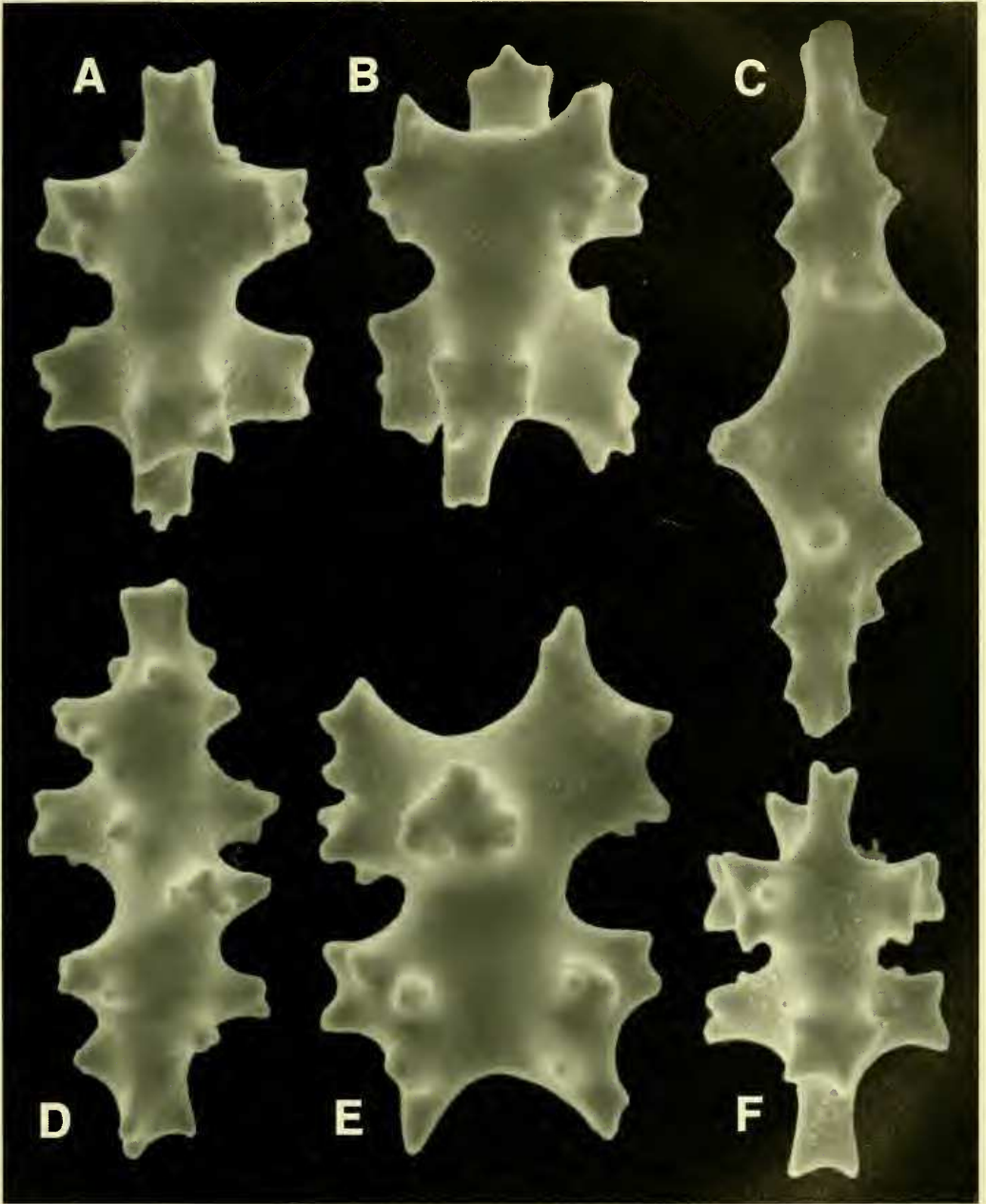


FIGURE 4. *Minabea phalloides*. Scanning electron micrographs of sclerites from the surface of the stalk. A. 0.05 mm; B. 0.07 mm; C. 0.15 mm; D. 0.12 mm; E. 0.08 mm; F. 0.06 mm.

Polyps. The polyps are evenly distributed throughout the polyparium. The preserved expanded anthocodiae average 2 mm in diameter, and have slender tentacles with 10–15 pinnules per side. The siphonozooids are numerous and conspicuous, disposed between the autozooids, each measuring approximately 0.4 mm in diameter (Fig. 1B).

Sclerites. The sclerites throughout the colonies are densely set and are predominantly radiates and spiny rodlike forms. A few triradiate or cross-shaped forms are also present. The rods of the polyparium are numerous and elongate, whereas any similar sclerites in the stalk are much fewer, shorter and stouter (Fig. 2). Surface samples may also include a few subsurface rods between 0.13 and 0.27 mm. These rods (Fig 2A, 3A–C) are relatively spiny, with smooth, conical to somewhat acute tubercles towards both ends, the middle portions often being devoid of prominences. Although the interior of the polyparium includes a few radiates immediately below the surface (0.04–0.09 mm), further within, the walls of the gastric cavities exclusively contain these spiny rods, numerous, often clustered, more-or-less longitudinally disposed, and 0.14–0.23 mm long (Fig. 1C, D). The surface of the stalk contains mostly six- and eight-radiates that are 0.06–0.12 mm long, and elongate forms, 0.12–0.15 mm long, with two girdles of prominences (Fig. 2C). The interior of the stalk has six- and eight-radiates, 0.04–0.10 mm long, and robust, sparsely ornamented spindles, 0.15 and 0.18 mm in length (Fig. 2D), which do not have a middle portion devoid of pronounced tubercles (Fig. 4C), as is the case with the rods of the polyparium (Fig. 3A–C). In addition, the tubercles of the stalk spindles are more pronounced than those of the polyparium rods (compare Fig. 2D with 2A).

Color in alcohol-preserved specimens. The color of the stalk is grey-white to cream white. The polyparia are pale yellow-orange, sometimes lighter distally approaching grey-white to cream white. The autozooids are white. The sclerites from the middle of the polyparium are pale yellow, while those of the stalks are colorless.

DISTRIBUTION. — New Zealand, 139–179 meters in depth; and Honshu, Japan, 250–270 meters in depth (Figs. 15C, 16).

REMARKS. — The holotype was not available for examination and cannot be located at present. In addition, the type locality is uncertain. Benham (1928:79) states, “A single colony was obtained by Hon. G. M. Thomson during the experimental fishery cruise in the G.S.Y. ‘Hinemoa,’ in 1915. Unfortunately neither the exact station at which it was dredged nor the depth was noted, but it seems probable that it was somewhere in Foveaux Strait.” All recently collected material is from the opposite end of the country, in the Bay of Plenty (Fig. 15C).

The holotype of *Minabea ozakii* Utinomi, 1957, for which the genus *Minabea* was originally proposed, cannot be located at present. The type locality is recorded as the Kii Strait, southwest of the town of Minabe, southern Honshu, and Utinomi’s description is sufficiently detailed to show that the Japanese specimen is morphologically indistinguishable from the New Zealand material of *Minabea phalloides*. Because of the lack of differentiating morphological characters, we here consider *Minabea ozakii* as a junior synonym of *Minabea phalloides*, despite the fact that the taxon is comprised of two remarkably disjunct populations.

Utinomi and Imahara (1976:211) considered *Anthomastus agilis* Tixier-Durivault, 1970 from New Caledonia to be a possible synonym of *Minabea phalloides*. However, Alderslade (1994) has shown the taxon of Tixier-Durivault to be included in the genus *Simularia*.

Paraminabea gen. nov.

Minabea (non Utinomi, 1957:139); Utinomi and Imahara, 1976 (in part):206. Bayer, 1981:913. Tixier-Durivault, 1987:154. Williams, 1992b (in part):2.

Bellonella (non Gray, 1862):Thomson and Henderson, 1905:274; Bayer, 1974:261; Faulkner and Chesher, 1979:267, pl. 22.

Alcyonium (non Linnaeus, 1758): Thomson and Mackinnon, 1910:174.

DIAGNOSIS. — Alcyoniid soft corals with colonies commonly unbranched and dome-shaped or hemispherical to digitiform, or rarely digitate/lobate with few branching processes. Polyps dimorphic. The distal polyparium arises from a proximal stalk that is variable in length. Polyps evenly distributed over surface of polyparium and capable of complete retraction, calyces and sclerites absent. Siphonozooids numerous to scarce, small to minute (< 0.3 mm in diameter; $< 1/3$ diameter of retracted autozooids), distributed between the autozooids. Sclerites of surface and interior of colony are densely set: mostly barrels and six- or eight-radiates; spindlelike forms derived from radiates, and tuberculate spheroids may also be present; seven-radiates or double stars sometimes occurring. Color red, orange, yellow or pinkish white to cream white.

DIVERSITY AND DISTRIBUTION. — Eight species in the genus are here considered valid (Table 1); with an Indo-West Pacific distribution from southeastern Africa, Seychelles, the Maldives, and Sri Lanka to Japan, Guam, Chuuk and Fiji (Figs. 15, 16); 1–370 m in depth.

TYPE SPECIES. — *Bellonella indica* Thomson and Henderson, 1905, here designated.

Paraminabea acronocephala (Williams, 1992)

Figs. 5B–E, 6, 7, 8, 9, 15B, 16

Minabea acronocephala Williams, 1992b:3. Gosliner, Behrens, and Williams 1996:35.

MATERIAL. — CAS 101094, Solomon Islands, N. Russell Group, Karomolun Island, 11 m depth, 14 November 1994, Gary C. Williams using SCUBA, one specimen in two pieces.

DIAGNOSIS. — Growth form clavate to torch-shaped with distal-most portion of stalk slightly wider than polyparium. Hemispherical polyparium represents distal-most $1/3$ of entire colony length. Sclerites are six- to eight-radiates and barrels, 0.05–0.11 mm long. Color of polyparium in the living animal as well as the wet-preserved specimen is deep yellow, with stalk pale orange.

DESCRIPTION. — **Growth form and size.** The specimen is 20 mm in length with a maximum width of 10 mm, unbranched and clavate, lamp-shaped to torch-shaped (Fig. 6A). The stalk and the polyparium are distinctly delimited by a somewhat undulating border. The polyparium is shorter than the conspicuous stalk. The stalk is prominent and elongate, the length being approximately twice its width. The proximal holdfast region of the stalk is spread. The distal-most portion of the stalk is distinctly flared and slightly wider than the polyparium, representing the widest portion of the entire colony. The polyparium is hemispherical and represents approximately 33% of the entire colony length, while the stalk and holdfast comprise the remaining 67% (Fig. 6A).

Polyps. The polyps are all tightly retracted. The autozooids are represented by slightly indented pits, evenly distributed over the surface of the polyparium. The siphonozooids are minute, indistinct, and scattered between the autozooids (Fig. 6B).

Sclerites. The sclerites throughout the specimen are radiates and robust barrels. Sclerites of the polyparium and stalk interior are generally larger and more robust than those of the surface coenenchyme. Sclerites from the surface of the polyparium are radiates and relatively narrow barrels, 0.05–0.09 mm in length (Fig. 7A); some of the radiates are only very sparsely ornamented and may be sclerites still in the process of developing. Sclerites from the interior of the polyparium are mostly robust barrels, often with distinct medial waists. Most of these vary between 0.08 and 0.12 mm in length (Fig. 7B). The surface of the stalk contains sclerites that are radiates and relatively small barrels, 0.05–0.08 mm in length (Fig. 7C). The interior of the stalk contains mostly robust and slightly larger barrels, 0.07–0.10 mm in length (Fig. 7D).

Color in living animal and alcohol-preserved specimen. The upper portion of the stalk, and the polyparium, are deep yellow, while the lower part of the stalk and holdfast are salmon orange. The sclerites of the polyparium are yellow, while those from the middle of the stalk are pale orange-yellow.

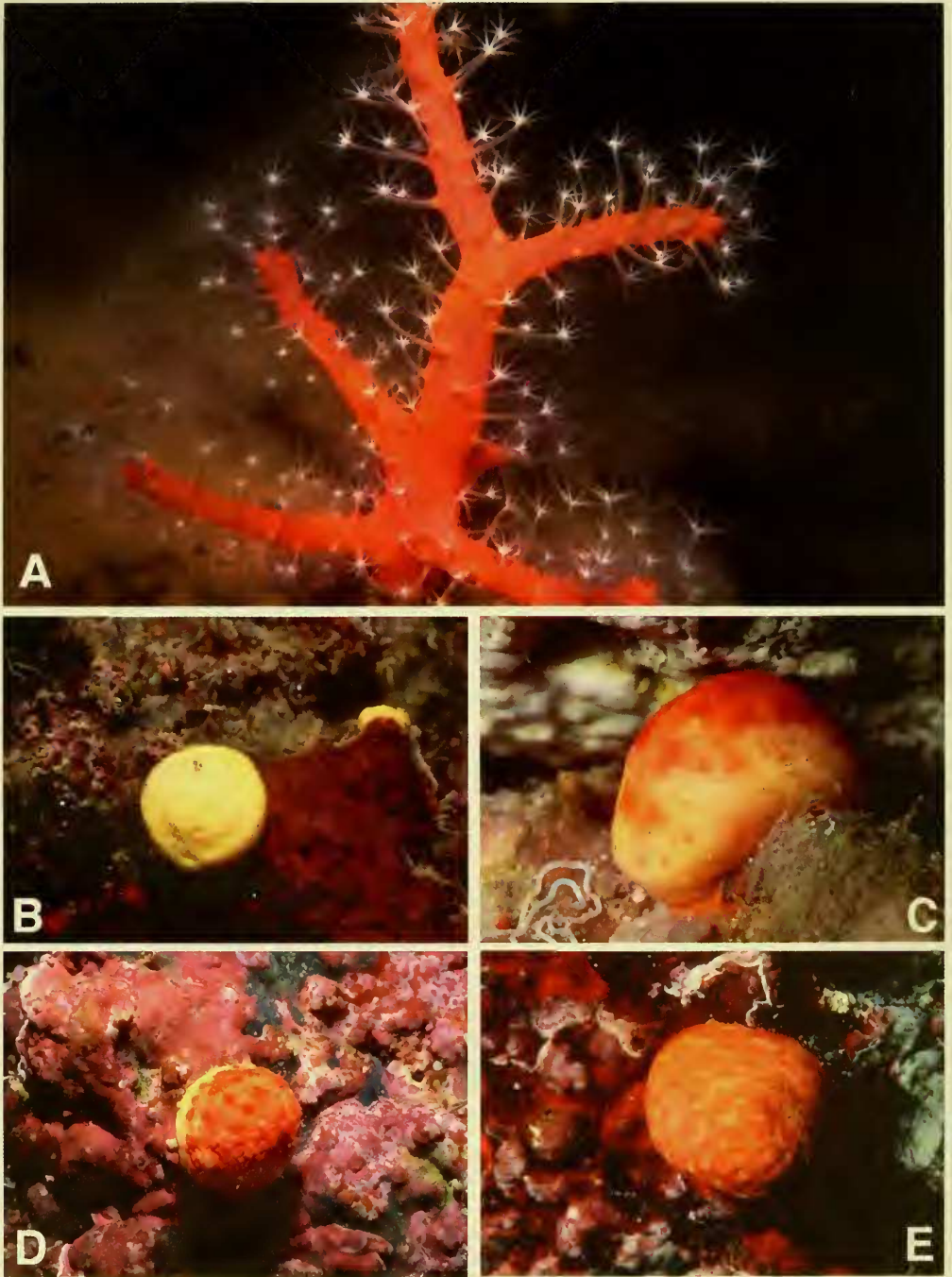


FIGURE 5. A. *Paraminabea arborea* sp. nov., underwater photograph of the paratype in life (NTM C-12559) from Zambales, Luzon, Philippines (photograph by Patrick Colin, CRRF). B-E. *Paraminabea acronocephala*. B. Underwater photograph of a yellow form in life, Banana Rock, Madang Barrier Reef, Papua New Guinea, 23–26 m depth, 19 June 1992 (photograph by Gary Williams, CAS); C. Underwater photograph of voucher specimen in life (CAS 094306) from Madang, Papua New Guinea (photograph by Gary Williams, CAS); D. Underwater photograph of a yellow and red form in life, Rasch Passage, Madang Barrier Reef, Papua New Guinea, 15–21 m depth, 17 June 1992 (photograph by Gary Williams, CAS); E. Underwater photograph of voucher specimen in life (CAS 111926) from Somosomo Straits, Fiji (photograph by Patrick Colin, CRRF).

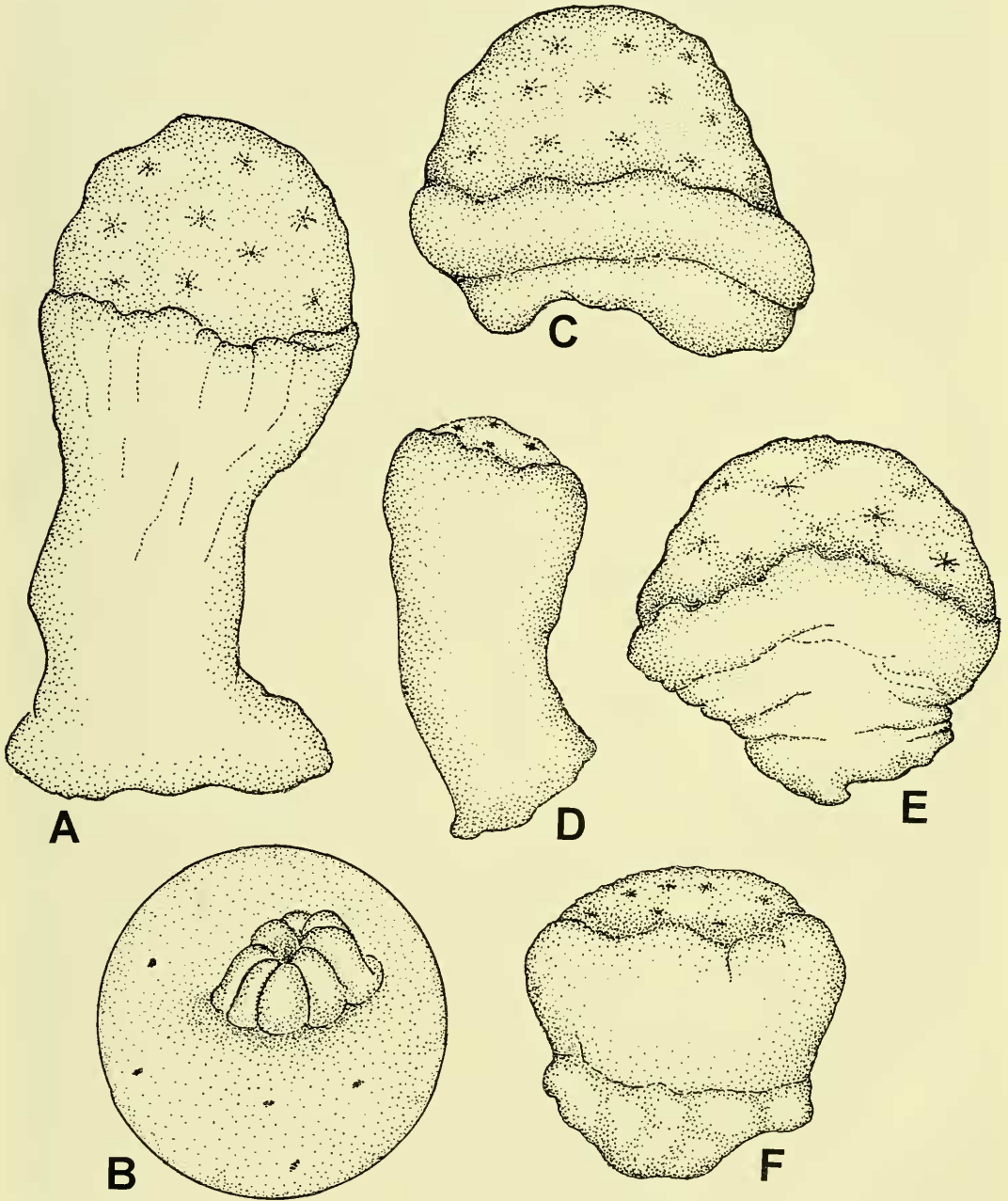


FIGURE 6. Phenotypic variation in *Paraminabea acronocephala*. A. Specimen from Solomon Islands, 20 mm long \times 10 mm wide (CAS 101094); B. Detail from the polyparium in A showing a single autozooid surrounded by five siphonozooids, diameter of figure 2.5 mm; C. Specimen from Fiji, 16 mm long \times 18 mm wide (CAS 111926). D-F. Specimens from Madang, Papua New Guinea. D. 13 mm long \times 7 mm wide (CAS 078417); E. 15 mm long \times 17 mm wide (CAS 094306); F. 6 mm long \times 8 mm wide (CAS 078417).

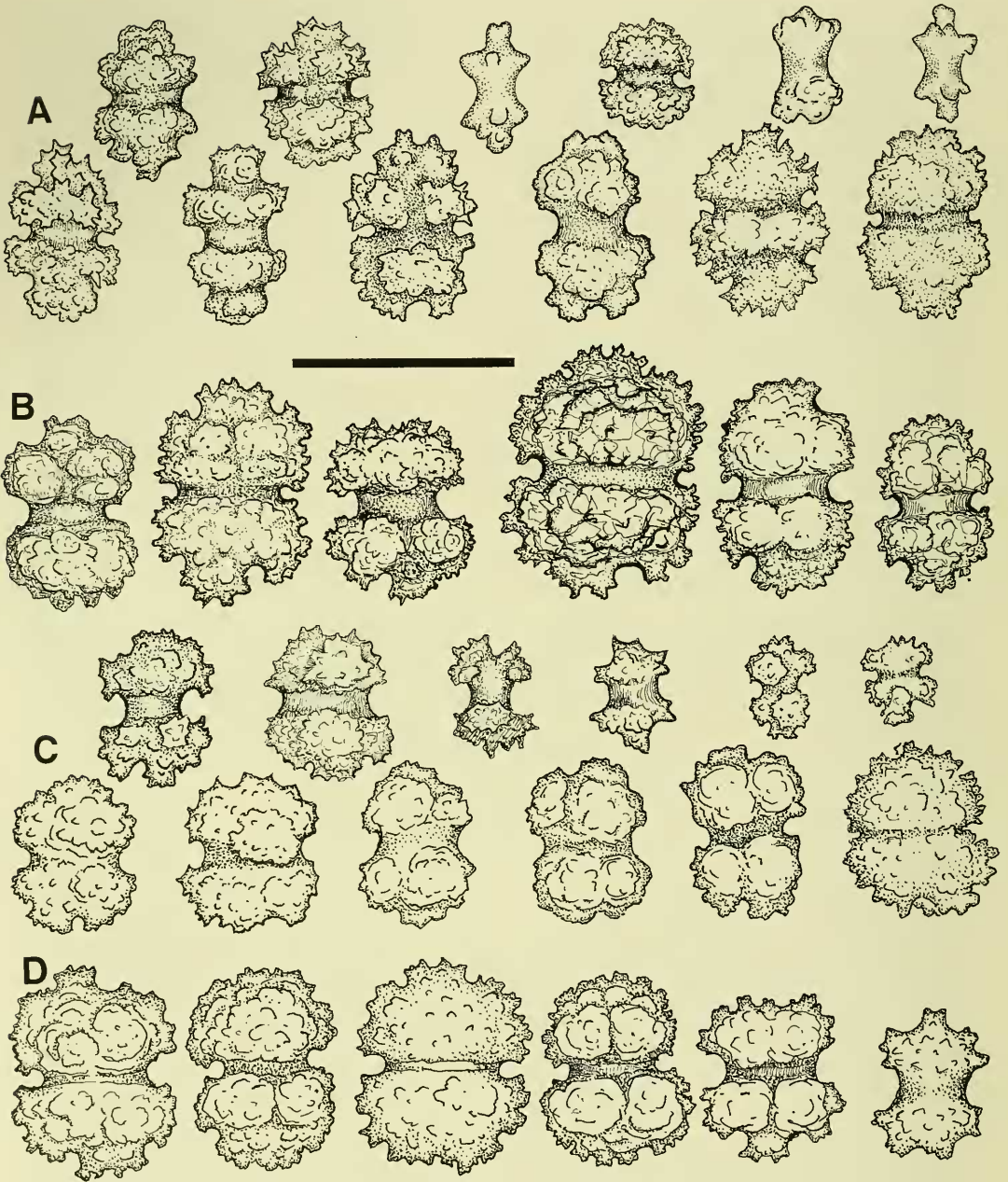


FIGURE 7. Sclerites of *Paraminabea acronocephala*. A. Sclerites from the surface of the polyparium; B. Sclerites from the interior of the polyparium; C. Sclerites from the surface of the stalk; D. Sclerites from the interior of the stalk. Scale bar = 0.1 mm.

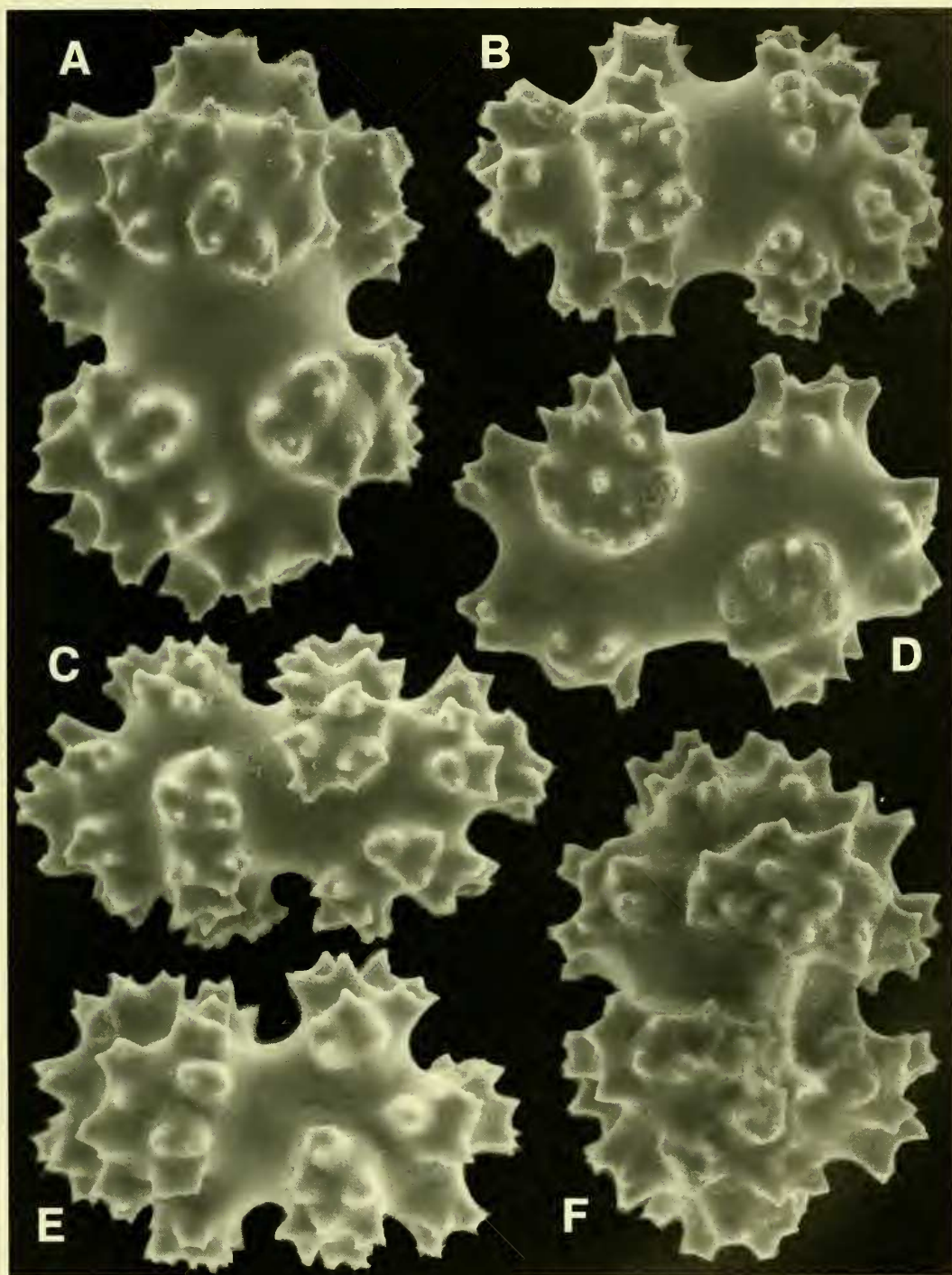


FIGURE 8. *Paraminabea acronocephala*. Scanning electron micrographs of sclerites from the surface of the polyparium of specimen shown in Figure 6A. A. 0.09 mm; B. 0.07 mm; C. 0.08 mm; D. 0.07 mm; E. 0.06 mm; F. 0.06 mm.

TABLE 1. Comparison of the world species of *Minabea* and *Paraminabea* (revised from Williams 1992:20).

Species	Colony shape and length	Sclerites	Color	Distribution and depth
<i>P. acronocephala</i> (Williams, 1992)	dome-shaped or clavate: low hemispherical to torch-shaped (4–20 mm)	barrels and six- to eight- radiates (0.05–0.13 mm)	yellow and/or orange, often with red retracted polyps; or entirely red-brown	New Guinea, Fiji, Solomon Is. (5–21 m)
<i>P. aldersladei</i> (Williams, 1992)	digitiform: elongate tapering (19–69 mm)	elongate barrels and eight-radiates (0.04–0.12 mm)	entirely yellow or red-orange; of yellow with red retracted polyps	New Guinea, NW Australia, Great Barrier Reef, Philippines, Solomon Is., Malay Archipelago, Palau, Chuuk (2–25 m)
<i>P. arborea</i> sp. nov.	digitate: with 3–6 fingerlike processes (49–64 mm)	robust barrels and six- to eight-radiates (0.04– 0.10 mm)	red-orange with yellow retracted polyps	Okinawa, Philippines (10–69 m)
<i>P. cosmarioides</i> (Williams, 1992)	digitiform: robust cylindrical (34–41 mm)	eight-radiates and rotund barrels (0.05–0.19 mm)	dull brown-orange	Transkei (South Africa) (250 m)
<i>P. goslineri</i> (Williams, 1992)	dome-shaped: low conical (3–10 mm)	double stars, six- and eight- radiates (0.05–0.12 mm)	uniform yellow	Guam (1–3 m)
<i>P. indica</i> (Thomson and Henderson, 1905)	digitiform: elongate cylindrical; or lobate with 2–3 lobes (20–40 mm)	robust barrels, six-, seven-, eight-radiates, double stars (0.04–0.11 mm)	crimson vermilion with yellow retracted polyps	Sri Lanka (“deep water”); Seychelles (71 m)
<i>P. kostiensis</i> (Williams, 1992)	digitiform: short cylindrical (20–30 mm)	eight-radiates, spindles and intermediates (0.06– 0.24 mm)	white with salmon pink retracted polyps	Natal (South Africa) (370 m)
<i>P. robusta</i> (Utinomi and Imahara, 1976)	digitiform: elongate tapering (57–170 mm)	radiates, robust barrels, and tuberculate spheroids (0.04–0.11 mm)	pale yellow-orange with yellow or orange retracted polyps	Japan (25–30 m)
<i>M. phalloides</i> (Benham, 1928)	digitiform: elongate tapering (43–73 mm)	radiates and spiny rods, and a few spindles (0.04–0.27 mm)	pale yellow-orange with cream white stalk; or dull orange to cinnamon	Japan (250–270 m); New Zealand (139–179 m)

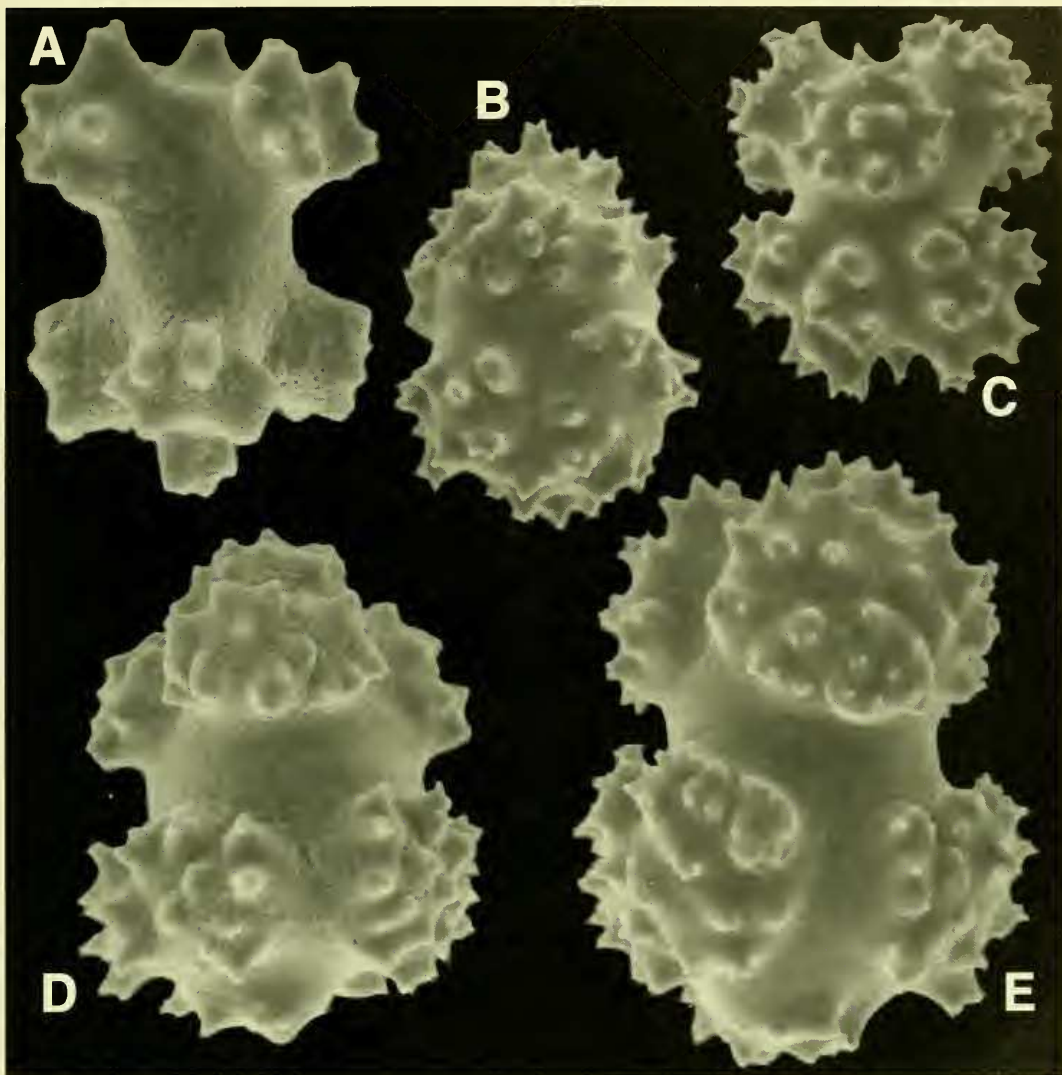


FIGURE 9. *Paraminabea acronocephala*. Scanning electron micrographs of sclerites from the surface of the stalk of specimen shown in Figure 6A. A. 0.05 mm; B. 0.08 mm; C. 0.07 mm; D. 0.08 mm; E. 0.07 mm.

DISTRIBUTION. — The specimen is from the Russell Group (Solomon Islands). This variable species is also known from the Madang region and the Louisiade Archipelago (Papua New Guinea), as well as Fiji (Williams 1992, and the present work) (Figs. 15B, 16).

REMARKS. — This specimen differs from all others known of the species by having a prominent, elongated stalk and hemispherical polyparium (see discussion of phenotypic variability).

Paraminabea arborea sp. nov.

Figs. 5A, 10, 11, 12, 13, 15A, 16

MATERIAL. — **HOLOTYPE:** CAS 112114, Japan, Ryukyu Islands, Okinawa, Serigaki, 68 m depth, 12 February 1995, Robert F. Bolland using SCUBA, one whole specimen. **PARATYPE:** NTM C-12559, Philippines, Luzon, Zambales, Luan Island near Masinloc Town (15° 29.06' N; 119° 54.41' E), 10–12 meters depth, 1 May 1995, Pat Colin using SCUBA, one whole specimen.

DIAGNOSIS. — Growth form digitate, with 3–6 somewhat curved fingerlike processes, rounded to slightly clavate distally, not pointed or tapered. Main trunk tapers distally. Stalk represents the proximal-most one sixth of the total body length. Sclerites mostly robust barrels (0.06–0.10 mm long) and six to eight radiates (0.04–0.06 mm long). Color in life as well as preserved is red-orange, with yellow dots representing retracted autozooids.

DESCRIPTION. — **Growth form and size.** The holotype is 64 mm long while the paratype is 49 mm in length. The branched polyparium arises from a short robust stalk. The polyparium comprises approximately 80% of the total length of the colony in the holotype, and approximately 87% in the paratype. The proximal-most portion of the holotype is represented by a holdfast region that spreads, and in the paratype it is slightly flared from the rest of the stalk. The holotype has six relatively narrow, digitate processes that are curved throughout their length, and are rounded or slightly clavate distally (Fig. 10). The paratype has four such processes. The digitate processes arise at different levels along the length of the main trunk, which is elongate, upright, and tapers distally.

Polyps. Several autozooids with their white anthocodiae protrude from the polyp apertures in the preserved holotype. Maximum diameter of the tentacle spread is 1.7 mm. Tentacles have about 18 pinnules arranged more or less in two rows down each edge. The siphonozooids are sparsely arranged between the autozooids and are minute (ca. 0.1 mm in diameter) (Fig. 10C). They appear as small yellow hemispherical protuberances on the surface of the polyparium (Fig. 5A).

Sclerites. Sclerites of the surface of the polyparium are mostly barrels 0.07–0.09 mm long and six- or eight-radiates 0.03–0.06 mm in length (Figs. 11A, 12), while those of the interior of the polyparium are slightly larger and more robust barrels, 0.10–0.11 mm in length (Fig. 11B). The surface of the stalk contains sclerites that are mostly six-radiates 0.04–0.08 mm long and robust barrels 0.09–0.11 mm in length (Figs. 11C, 13). The interior of the stalk contains mostly barrels 0.07–0.11 mm in length; some of these may approach tuberculate spheroids (Fig. 11D).

Color of living and wet-preserved material. The color of the coenenchyme is predominantly red-orange approaching brick red. The expanded autozooids are white, and the numerous yellow spots on the surface of the colony are the closed polyp apertures. The sclerites are very pale orange to colorless and mostly transparent.

DISTRIBUTION. — Luzon (Philippines) and Okinawa (Ryukyu Islands, Japan); 10–68 m depth (Figs. 15A, 16).

ETYMOLOGY. — The specific epithet is derived from the Latin, *arbor* (tree); in reference to the sparsely branched growth form characteristic of this species.

REMARKS. — This species is the only member of the genus with a digitate/lobate growth form besides *Paraminabea indica* (see description below). *Paraminabea indica* can be digitiform or lobate with thick short lobes arising from a short common base at roughly the same level (Fig. 14), while *P. arborea* is digitate with several narrow fingerlike processes arising from an elongate common trunk at different levels (Fig. 10). All other described species are unbranched and digitiform to dome-shaped (Table 1). Some species of the alcyoniid genus *Eleutherobia* may be lobate to digitate such as *E. somaliensis* Verseveldt and Bayer, 1988, which superficially resembles *Paraminabea arborea*. However, *Eleutherobia* differs from *Paraminabea* in having monomorphic polyps, not dimorphic ones.

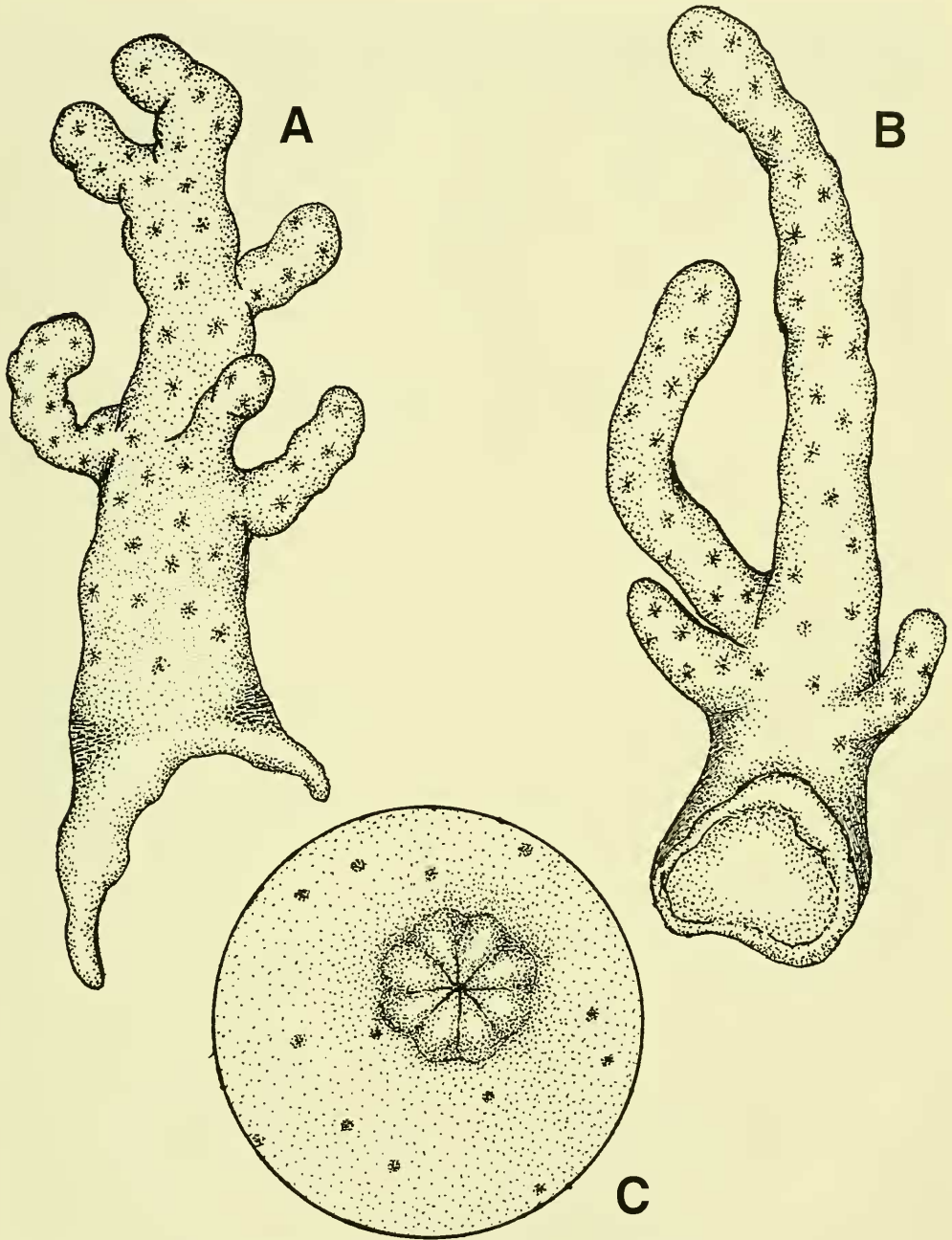


FIGURE 10. *Paraminabea arborea* sp. nov. A. Holotype, 64 mm in length; B. Paratype, 49 mm in length; C. Detail of the polyparium surface showing one autozooid surrounded by thirteen siphonozooids, diameter of diagram 2.7 mm.

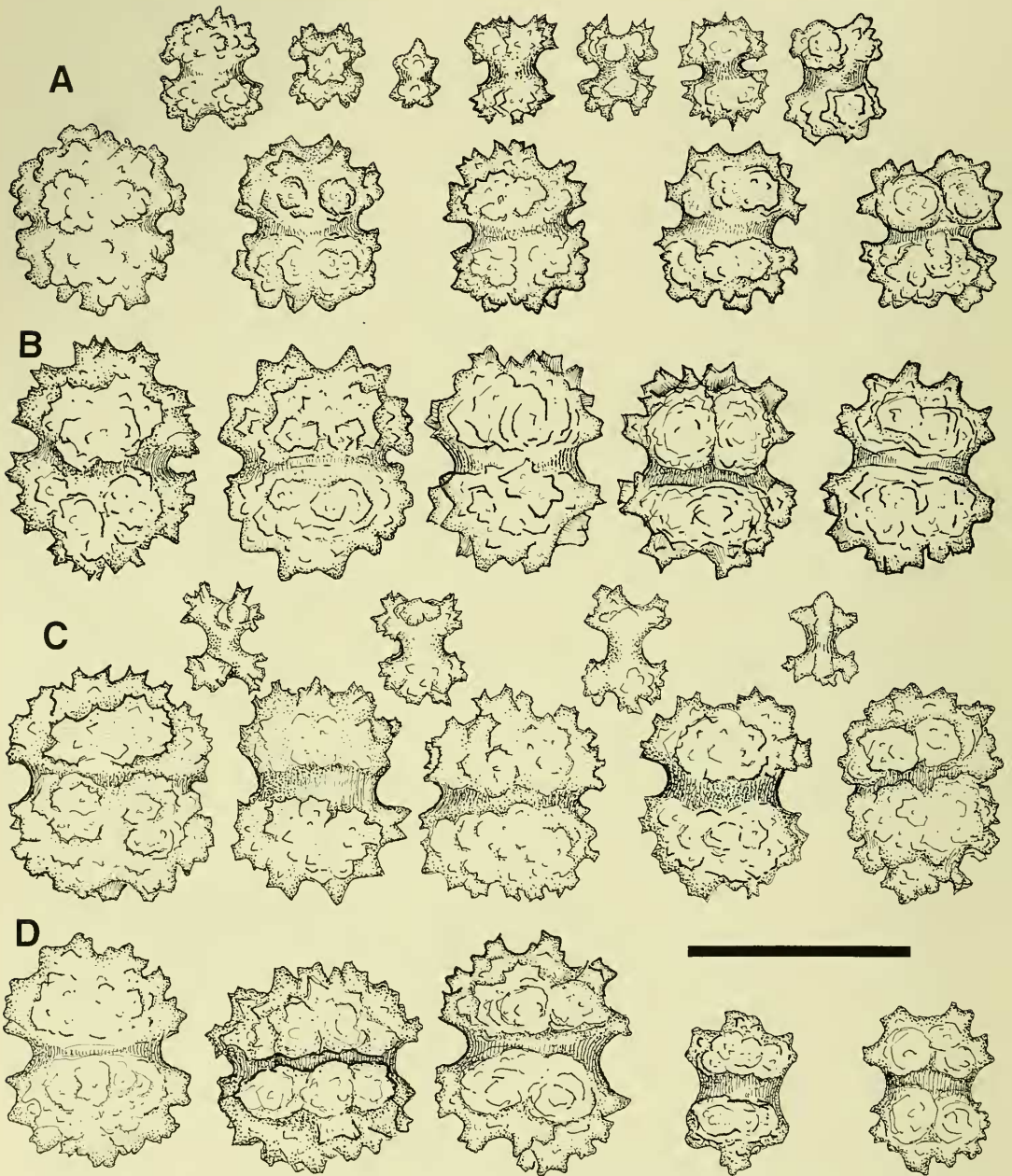


FIGURE 11. Sclerites of *Paraminabea arborea* sp. nov. A. Sclerites from the surface of the polyparium; B. Sclerites from the interior of the polyparium; C. Sclerites for the surface of the stalk; D. Sclerites from the interior of the stalk. Scale bar = 0.1 mm.

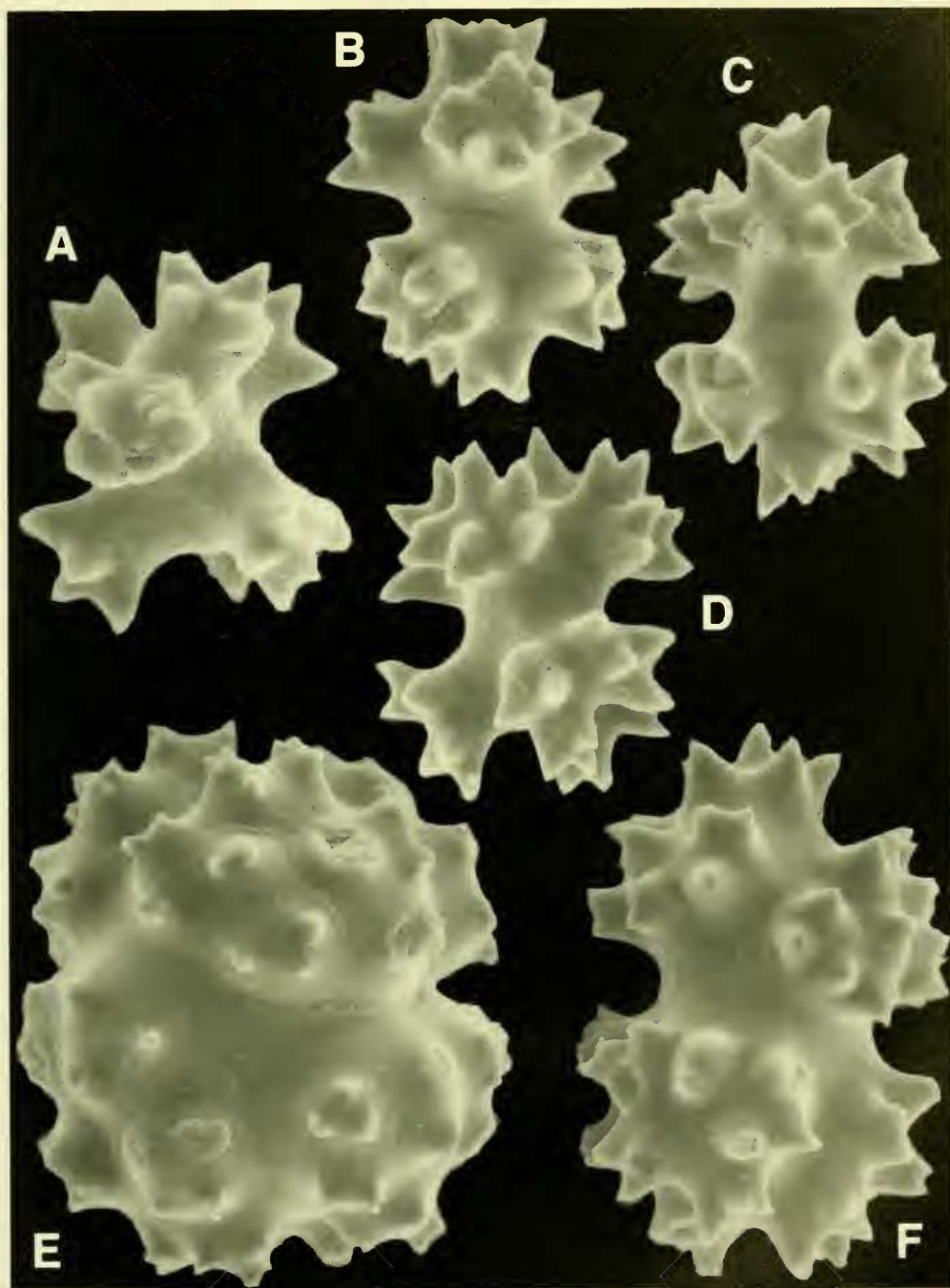


FIGURE 12. *Paraminabea arborea* sp. nov. Scanning electron micrographs of sclerites from the surface of the polyparium of the holotype. A. 0.04 mm; B. 0.05 mm; C. 0.05 mm; D. 0.04 mm; E. 0.08 mm; F. 0.07 mm.

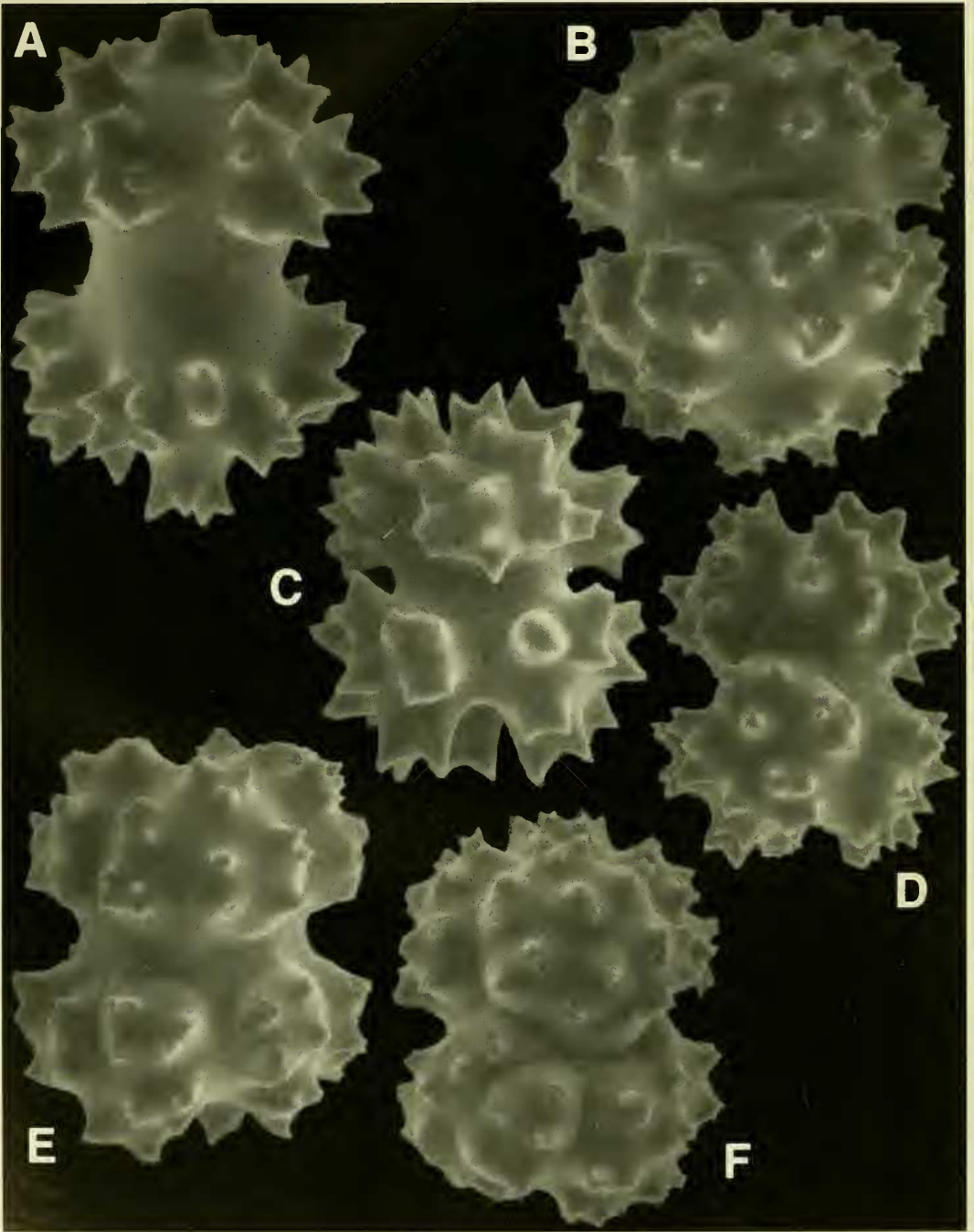


FIGURE 13. *Paraminabea arborea* sp. nov. Scanning electron micrographs of sclerites from the surface of the stalk of the holotype. A. 0.07 mm; B. 0.10 mm; C. 0.06 mm; D. 0.08 mm; E. 0.09 mm; F. 0.08 mm.

***Paraminabea indica* (Thomson and Henderson, 1905)**

Figs. 14, 15

Bellonella indica Thomson and Henderson, 1905:274, pl. 6, fig.5. *Non* Bayer, 1974:261. *Non* Faulkner and Chesher, 1979:267, pl. 22.

Alcyonium indicum Thomson and Mackinnon, 1910:174, pl. 12, fig. 7.

Minabea indica: Williams, 1992b:14, figs. 10, 11.

MATERIAL. — HOLOTYPE: NHM Reg. No. 1933.3 13/206 (labeled as *Nidalia indica*). Sri Lanka. South of Galle: deep water, Sir J. A. Thomson Collections, one specimen in which part of the polyparium has been cut away longitudinally and is missing.

NHM Reg. No. 1912.2.24.72. Seychelles, 39 fathoms; *Alcyonium indicum* specimen of Thomson and Mackinnon.

REDESCRIPTION. — A redescription of the holotype was provided by Williams (1992), but the sclerites are figured in the present paper (Fig. 14D–Q) for comparative purposes. A redescription of the specimen of *Alcyonium indicum* described by Thomson and Mackinnon in 1910 follows.

Growth form and size. The specimen is 40 mm in height. The lobate polyparium arises from the stout stalk (Fig. 14A). A portion of the surface of the stalk has been cut away. The stalk measures 15 mm at its widest diameter. The polyparium comprises no more than 50% of the length of the specimen. The three lobes of the polyparium arise from the stalk at approximately the same level. One of these three lobes has been cut away and is missing. The base of this lobe is 6 mm in diameter. The remaining lobes are short, stout, and rounded at the tips, not tapering. The central one is 17 mm long and 7 mm wide, while the lateral one is 16 mm long by 8 mm wide.

Polyps. The autozooids appear as small yellow spots distributed evenly over the surface of the polyparium. Some of these form low, rounded protuberances (ca. 0.8 mm in diameter). The siphonozooids are apparently sparsely distributed, and are minute and difficult to observe in the tightly retracted specimen. Some occur only as very minute pores between the autozooids.

Sclerites. The sclerites are robust barrels (many of which are only slightly longer than wide), radiates that vary as six-, seven-, or eight-radiates, and some forms that approach double stars. Sclerites from the polyparium surface and interior are similar, and are more variable in form than the stalk sclerites. The polyparium has barrels, radiates, and double stars, while the surface and interior of the stalk contains many robust barrels with some radiates (Fig. 14B, C). These sclerite characters are similar to that of the holotype of *Paraminabea indica* (Fig. 14E–Q).

Color of alcohol-preserved specimen. The specimen is uniform reddish orange, with lemon yellow dots representing the closed autozoid apertures.

DISTRIBUTION. — Indian Ocean: Sri Lanka (“deep water,” Thomson and Henderson 1905:275), the Seychelles (71 m, Thomson and MacKinnon 1910:174), and possibly the Maldiv Islands (ca. 10 m, Schuhmacher and Hinterkircher 1996:50)(Fig. 15).

REMARKS. — Both *Paraminabea indica* and *P. arborea* sp. nov. may appear branched (digitate or lobate), the only two species in the genus observed to have this growth form. Because of this superficial similarity, it was necessary to compare the specimens of *P. indica* with those of the new species. (See Remarks for *P. arborea* sp. nov. for differentiation of these taxa).

The lobate specimen of *Alcyonium indicum* was compared with that of the digitiform holotype of *Paraminabea indica* in order to ascertain whether the two are indeed conspecific or represent two separate species. Comparative investigation shows them to be conspecific in our opinion. Sclerite form and distribution are consistent in both specimens, as is the fact that the polyparia and the stalks of both specimens each occupy approximately half of the total specimen length.

DISCUSSION

PHENOTYPIC VARIABILITY. — The proliferation of intraspecific phenotypic variability in sedentary marine animals has been noted or described by several authors, including Veron (1986:60; 1995:14) and Miller (1995) for scleractinian corals, and for octocorals Hickson (1907:25–36), J. S. Thomson (1921:165, 166), Groot and Weinberg (1982:293), Verseveldt (1980, 1982, 1983), and Williams (1986:255; 1992a:282; 1992c:383, 384). The high degree of variation in many soft corals is at least partly attributable to localized isolation of populations, lack of mobility in adults, and ephemeral larval stages with limited or short-range dispersal capabilities (Williams 1986:255).

Potts (1984:48) linked a potential cause of prolific variability in Indo-Pacific reef corals to chronic environmental disturbances such as sea level fluctuations associated with glacial cycles. Veron (1995:126) stated that glacio-eustatic changes have affected tropical western Pacific reef coral diversity to a greater degree than in other areas of the world, due largely to the vast extent of shallow-water habitat in the region. These pronounced environmental perturbations have produced a complex mosaic of faunas over time, through the alternation of environmental regimes (marine vs. terrestrial), the isolation of refugia, and the subsequent repopulation of previously non-marine areas with the concomitant overlap of relictual forms from the various high diversity refugia.

Millard (1978:182), working with hydroids, concluded that at least two factors are indicators of an active region of evolutionary radiation: the proliferation of intraspecific phenotypic variation and a preponderance of endemic taxa. Regarding the octocoral fauna, Williams (1992c:384) suggested that in the region of overlap between the Indo-Pacific and the Cape Endemic Province in southern Africa, a high degree of endemism is derived from older and well-established components of the fauna, while the prolific phenotypic variability observed in these endemics is associated with a more recent result of repetitive glacio-eustatic disturbances during the past several million years.

Related to this, regarding genotypic variation, Solé-Cava and Thorpe (1991:66, 69) provide evidence for very high levels of genetic variation for marine sponges and coelenterates in general.

Figure 16 shows the ranges of the six presumably endemic species of *Minabea* and *Paraminabea* in the western Pacific. Of these six, *Paraminabea acronocephala* exemplifies, by far, the greatest range of phenotypic variation regarding growth form and color (Fig. 6). Williams (1992b:5, fig 2D) illustrates variation in colony shape at the type locality of this species.

Recently collected material from throughout the range of the species shows a wide spectrum of variation in growth form. The specimen from the Solomon Islands described above (CAS 101094) has an elongate stalk that flares toward its distal end, which represents the widest portion of the entire colony. The polyparium is hemispherical and is narrower than the distal part of the stalk. The stalk represents two thirds while the polyparium is approximately one third of the total colony length (Fig. 6A). The specimen is bicolored, deep yellow and salmon orange.

A recently collected specimen from Fiji (CAS 111926) (Figs. 5E, 6C) resembles the Solomon Islands material except that the stalk is extremely short. The polyparium is hemispherical and narrower than the smooth bandlike upper portion of the stalk. The holdfast and lower portion of the stalk are < 5 mm in length, and comprise < 5% of the total colony length. Color of the specimen is uniform rust orange to reddish brown.

Somewhat similar to the Fiji material is a specimen from Papua New Guinea (CAS 078417) (Figs 5C, 6E). It also has a hemispherical polyparium atop a short stalk. The uppermost portion of the stalk is smooth and bandlike and exceeds the width of the polyparium. The lower portion of the stalk tapers proximally. The stalk and holdfast constitute approximately 50% of the length of the specimen. Color is yellow-orange with retracted autozooids shown as red eight-pointed stars on the surface of the polyparium.

Two other specimens, also from the north coast of Papua New Guinea (both CAS 078417) (Figs. 6D, F) differ significantly from those with hemispheric polyparia, by having relatively flattened or

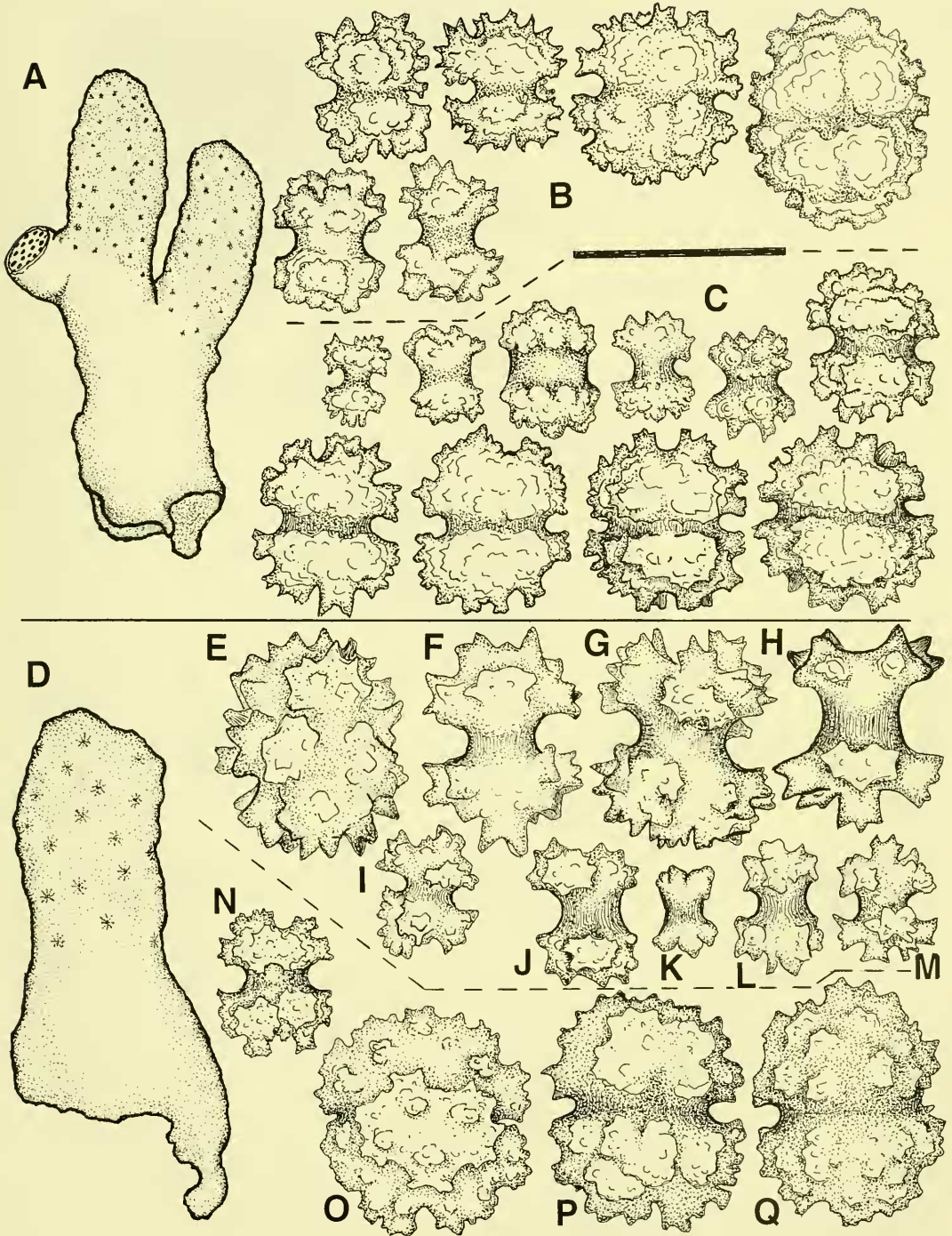


FIGURE 14. *Paraminabea indica*. A. Specimen of "*Alcyonium indicum*," described by Thomson and Mackinnon (1910:174, pl. 12, fig. 7) from the Seychelles, 40 mm in length; B. Sclerites from the surface of the stalk; C. Sclerites from the surface of the polyparium, scale bar = 0.1 mm; D. Holotype of *Bellonella indica* Thomson and Henderson (1905:274, pl. 6, fig. 5) from Sri Lanka, 20 mm in length. E–M. Sclerites from the surface of the polyparium. E. 0.50 mm; F. 0.06 mm; G. 0.05 mm; H. 0.05 mm; I. 0.05 mm; J. 0.07 mm; K. 0.05 mm; L. 0.07 mm; M. 0.07 mm. N–Q. Sclerites from the surface of the stalk. N. 0.08 mm; O. 0.08 mm; P. 0.08 mm; Q. 0.07 mm.

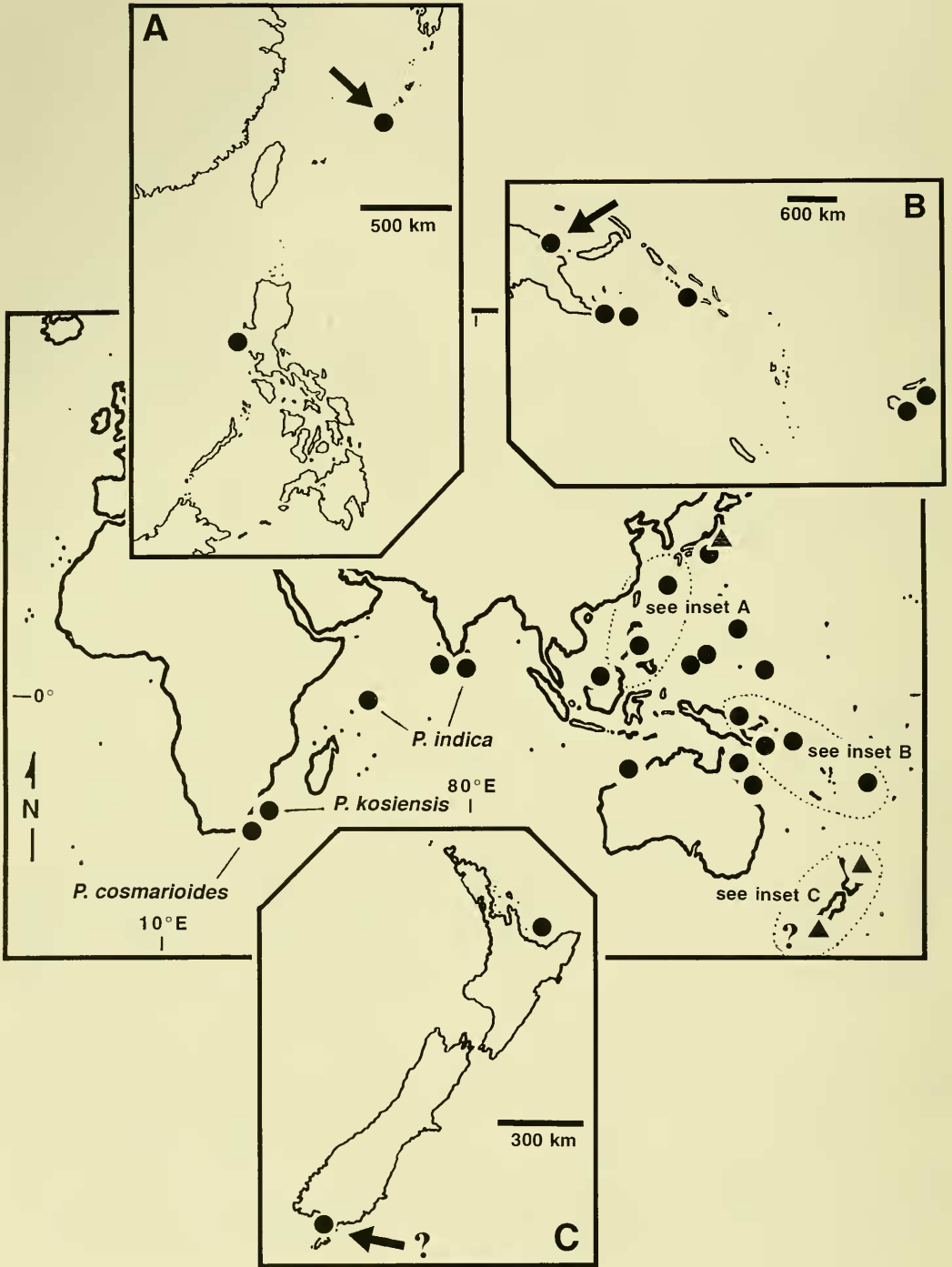


FIGURE 15. Maps of the Indo-West Pacific showing distribution of the genera *Minabea* (▲) and *Paraminabea* (●). A. China and Philippine Sea, showing collecting stations for *Paraminabea arborea* sp. nov.; B. Melanesia showing collecting stations for *Paraminabea acronocephala*; C. New Zealand collecting stations for *Minabea phalloides*. Arrows show type localities.

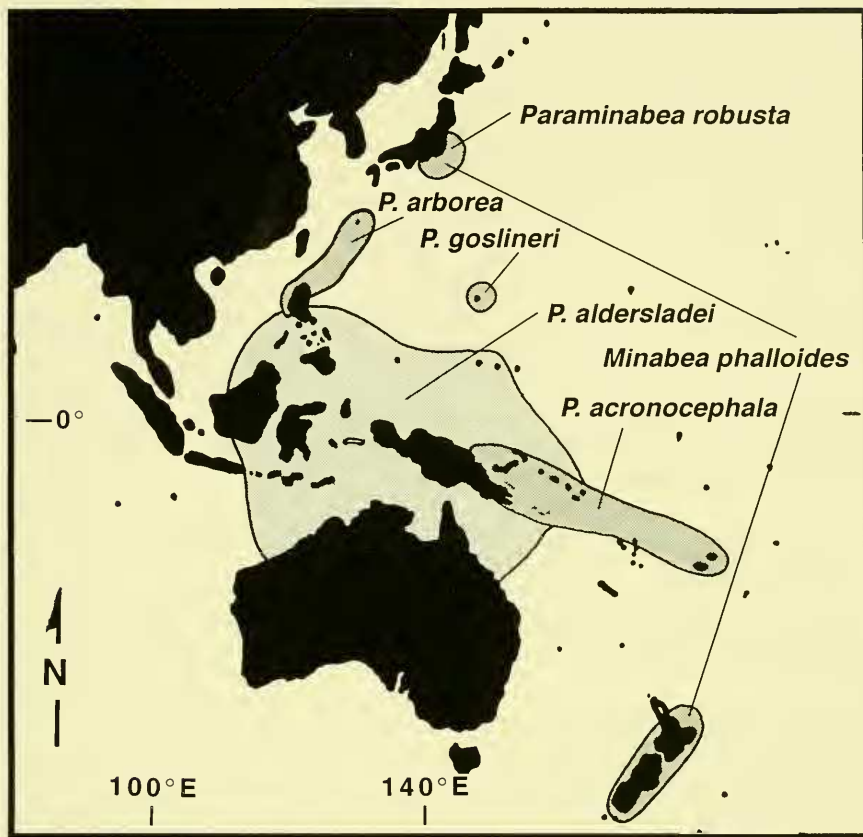


FIGURE 16. Map of the western Pacific Ocean showing geographic ranges for five species of the genus *Paraminabea* and the monotypic genus *Minabea*.

low rounded polyparia where the polyps are restricted to the distal-most extremity of the colony. The first-mentioned specimen has an elongated stalk while the second is dome-shaped with a shorter stalk. Both specimens show the distal-most portion of the stalk as the widest portion, a feature that is characteristic for the species.

Color of Bismarck Sea material is variable, from uniformly yellow or orange-red to bicolored yellow and orange with varying amounts of red-orange. Some specimens are yellow with red polyparia or with retracted autozooids showing as red eight-pointed stars on the polyparium surface.

DISTRIBUTION OF THE GENERA *MINABEA* AND *PARAMINABEA* (see Table 1; Figs. 15, 16). — These genera are recorded from the following localities, and range in depth from 1–370 m (Williams, 1992b:12, 17). First records are shown in parenthesis. **Indian Ocean:** Transkei and Natal, South Africa (Williams 1992a:314 for *Paraminabea cosmarioides* and *P. kosiensis*); Maldive Islands (Schuhmacher and Hinterkircher 1996:50 for *Paraminabea* sp. indet.); Seychelles (Thomson and MacKinnon 1910:174 for *Paraminabea indica* as *Alcyonium indicum*); Sri Lanka (Thomson and Henderson 1905:274 for *Paraminabea indica* as *Bellonella indica*); Rowley Shoals, Western Australia (Williams 1992b:7 for *Paraminabea aldersladei*). **Western Pacific Ocean:** Malaysian Borneo, the Philippines, and the Solomon Islands (Gosliner, Behrens, and Williams, 1996:35 for *Paraminabea aldersladei* and *P. acronocephala*); Great Barrier Reef, Papua New Guinea, Fiji, and Guam (Williams 1992b: 5, 13 for *Paraminabea aldersladei*, *P. acronocephala*, and *P. goslineri*); Palau (Bayer

1974:261 for *Paraminabea aldersladei* as *Bellonella indica*); New Zealand (Benham 1928:79 for *Minabea phalloides* as *Anthomastus phalloides*); Okinawa (present work for *Paraminabea arborea*); Honshu, Japan (Utinomi 1957:144 for *Minabea phalloides* as *M. ozakii*); Chuuk, Federated States of Micronesia (present work, CAS No. 096509, *Paraminabea aldersladei*,).

Of the six presumably endemic species in the western Pacific (*Minabea phalloides*, *Paraminabea acronocephala*, *P. aldersladei*, *P. arborea* sp. nov., *P. goslineri*, and *P. robusta*), *P. aldersladei* shows the greatest contiguous range of distribution, as well as some limited sympatry with *P. arborea* in the northwest and *P. acronocephala* in the east. *Minabea phalloides* and *Paraminabea robusta* also show overlapping distributions. *Minabea phalloides* is the only taxon with a distinct disjunct distribution (Fig. 16).

Regarding bathymetrics, *Minabea* and *Paraminabea* show wide depth distributions, unlike other genera of the Alcyoniidae such as *Simularia*, *Lobophytum*, *Sarcophytum*, and *Cladiella*. *Minabea* and *Paraminabea* are azooxanthellate taxa, differing in this regard from the other four genera, which are zooxanthellate and restricted to the relatively shallow water of coral reefs. The lack of zooxanthellae allows *Minabea* and *Paraminabea* to inhabit a wide range of depths, as well as a greater variety of habitats such as caves and alcoves.

KEY TO THE GENERA OF ALCYONIIDAE WITH DIMORPHIC POLYPS
(Revised from Williams 1990:34)

A revised key is provided here, which utilizes new data and enables easy differentiation of the various dimorphic alcyoniid taxa.

- 1. Colonies with trimorphic polyps; mesozooids present *Heteropolypus*
- Colonies with dimorphic polyps only; mesozooids absent 2
- 2. Polyparium capable of partial or complete retraction into the stalk 3
- Polyparium incapable of partial or complete retraction into the stalk 4
- 3. Polyps disposed on several digitiform lobes that are capable of at least partial retraction into the stalk. Stalk not covered with a horny cuticle *Carotalcyon*
- Polyps disposed on a rounded capitulum that is capable of complete retraction into the stalk. Stalk covered with a horny cuticle *Malacacanthus*
- 4. Colonies capitate with a hemispherical or spherical capitulum, digitiform with a tapering polyparium, or digitate/lobate 5
- Colonies with a broad polyparium either flared and discoidal often with deep open marginal folds, or surface with numerous often crowded closed folds or lobes that vary from low and hemispherical to digitiform or ridgelike 9
- 5. Colonies capitate 6
- Colonies digitiform or digitate/lobate 7
- 6. Coenenchymal sclerites are double stars and spiny rods *Anthomastus* (including *Bathyalcyon*)
- Coenenchymal sclerites are eight radiates and/or double stars, barrels and tuberculated spheroids *Verseveldtia*
- 7. Sclerites are numerous stout thorn clubs *Acrophytum*
- Sclerites are mostly radiates, sometimes with spindles or spiny rods 8
- 8. Sclerites are predominantly radiates and spiny rodlike forms. Siphonozooids are large (0.4–0.7 mm in diameter; or 1/3–1/2 the diameter of retracted autozooids) *Minabea*
- Sclerites are predominantly radiates, sometimes barrels, double stars, or spindles derived from radiates. Siphonozooids are small to minute (< 0.4 mm in diameter; or < 1/3 the diameter of retracted autozooids) *Paraminabea*
- 9. Polyparium is broadly flared and discoidal often with deep open marginal folds. Surface of polyparium smooth. Coenenchymal sclerites are small clubs and strong spindles with irregularly arranged tubercles *Sarcophyton*
- Polyparium margin with numerous, often crowded, closed folds or lobes that vary from low and hemispherical to digitiform. Surface of polyparium often with lobes or plications. Coenenchymal sclerites are spindles with tubercles often arranged in transverse girdles *Lobophytum*

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